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Brown Hotel, Louisville, Kentucky
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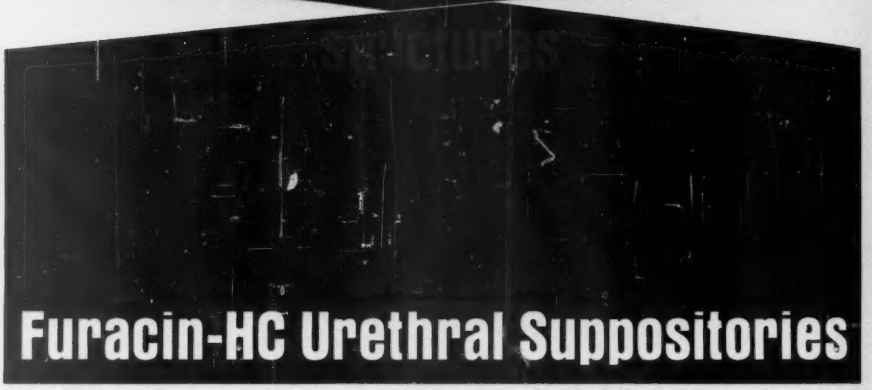

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1. Roll, W. A., and Waller, J. I.: J. Urol., Balt. 81:289, 1959.

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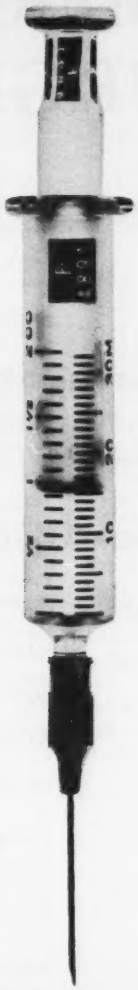

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TREATMENT OF PERIPHERAL ARTERY ANEURYSMS*

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INTRODUCTION

Aneurysmal dilation may occur at any site along a peripheral artery. It is recognized that certain sites are predisposed to aneurysmal formation in the degenerative group of arterial diseases; for example, arteriosclerotic aneurysms of the femoral system are more frequently seen in the popliteal spaces in which the artery is subjected to more acute bending and is more superficial. Trauma, conversely, has no predisposing site, except that selected by ill fortune. With the increasing population and the concomitant sidewalk social incompatibilities, and with an ever increasing number of traumatic occurrences on the highway, we are able to view post-traumatic aneurysmal formation more frequently. With better medical care, antibiotics, and other new drugs, longevity increases and brings a higher percentage of degenerative type arterial diseases and their incidence of aneurysmal formation.

Arterial aneurysms classically fall into three groups, the fusiform, in which the entire wall is dilated for considerable distance; true aneurysms, in which the sac is composed of the vessel structure; and false aneurysms, in which the sac is formed by surrounding structures. Aneurysms are further divided into congenital and acquired groups. The acquired group includes as etiologic factors degeneration from embolism, fungus invasion, arteritis, cancer, lead, tuberculosis, atherosclerosis, syphilis and x-ray.

* This work was supported by the John A. Hartford Foundation, Inc.

† From the Surgical Service of the Roper Hospital and the Medical College of South Carolina, Charleston, South Carolina.

It is the purpose of this paper to present cases which include the typical as well as some unusual types of peripheral artery aneurysms and to show the ease or complexity of their diagnoses and treatment.

CASE REPORTS

Popliteal Aneurysm of Syphilitic Origin

Case 1. J. B., No. 13934, a Negro man, aged 68, first noted spontaneous swelling in the left popliteal region 17 months before admission. The mass gradually enlarged, was noted to pulsate, and produced pain in the leg distally. In the several months before admission, paresthesias were also noted in the leg. Upon admission, there was a 15- by 12-cm. firm, pulsating mass in the left popliteal space. There was a distinct bruit over this mass. The Wassermann and Kline tests were positive. A diagnosis was made of false aneurysm of the popliteal artery secondary to luetic arteritis.

At operation on June 30, 1953, a false aneurysmal sac was encountered. The sac measured approximately 10 cm. in diameter and was filled with organized clot. The sac was opened, excised and the defect in the arterial wall was sutured in an everting manner with continuous 5-0 arterial silk.

Postoperatively, the popliteal artery and its branches were pulsatile. The patient's postoperative course was uncomplicated, and he has continued in good health (fig. 1, *A* and *B*).

Popliteal Aneurysm of Arteriosclerotic Origin

Case 2. J. A. H., No. 15177, a white man, aged 76, noted a small swelling in the lower medial aspect of his right thigh approximately 6 months before admission. Three days before admission he experienced sudden swelling, marked pain in this area, and sensory loss in the right leg. On physical

examination there was a tense pulsatile mass approximately 17- by 14-cm. in the medial aspect of the right distal thigh. A thrill and bruit were present over the proximal part of the swelling, and the superficial veins were dilated over the lower thigh and leg. There was pitting edema of the right leg. A diagnosis was made of expanding arteriosclerotic aneurysm of the right distal femoral and proximal popliteal arteries.

On May 3, 1958, at operation, a large aneurysm of the right popliteal artery was found with extravasation of blood into adjacent tissues. The aneurysm was approximately 14 cm. in greatest diameter. It was resected and replaced by an Edwards-Tapp nylon graft. At the end of the procedure, the skin of the foot and toes was of good color, and there were normal pulsations in the dorsalis pedis artery. At the time of discharge on May 17, 1958, the patient was ambulatory and without pain in the leg. Until his death, caused by coronary occlusion about 1 year later, he had no complaints referable to the leg (fig. 2).

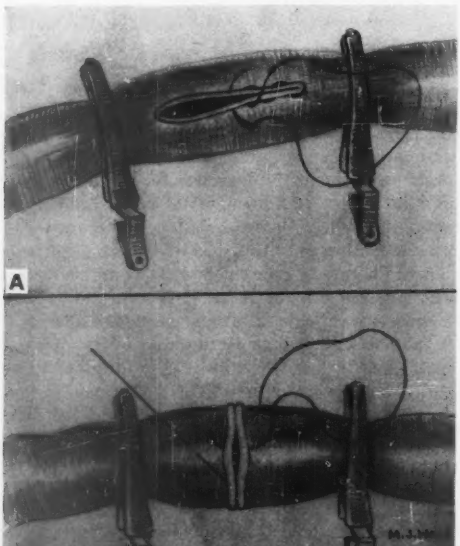

FIG. 1. *A*. This illustration shows the method of repair in the case of J. B. with luetic arteritis and subsequent false aneurysm formation. The sac has been dissected away, and the defect is closed with continuous everting 5-0 arterial silk mattress type suture. *B*. This illustrates the same type of repair when used for end-to-end anastomosis.

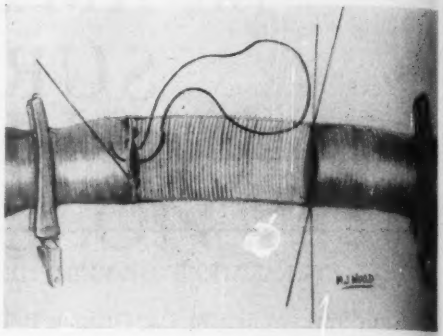

FIG. 2. This illustration shows the type of repair used in the case of J. A. H. with arteriosclerotic aneurysm of the popliteal artery. The graft is a plastic prosthetic type. The type of suture line varies; the one illustrated above is the continuous everting type with 5-0 arterial silk.

Traumatic Aneurysm of the Popliteal Artery

Case 3. T. D., No. A67535, a Negro man, aged 37, received a .22 caliber bullet wound to his left popliteal region 8 years before admission. The patient remained asymptomatic for 6½ years and then began to note swelling in the region of injury. Two weeks before admission, in April 1957, a definite painful mass became discernible. On physical examination, there was noted in the left popliteal region a scar of the old wound and a 12- by 10-cm. pulsatile mass over which could be heard a bruit. At operation on April 12, 1957, a large false aneurysm of the popliteal artery was found. The sac and 7 cm. of the artery were excised and replaced with an arterial homograft. The peripheral pulses were re-established, and he was discharged from the hospital 13 days after operation (fig. 3).

Gluteal Artery Aneurysm of Arteriosclerotic Origin

Case 4. R. J., No. A85332, a Negro man, aged 42, was admitted on June 10, 1958, with the chief complaint of swelling of the left buttock and pain in the left leg. A year and a half before admission, the patient began to notice pain in each calf which progressively involved the posterior thighs and the gluteal region. Approximately 6 months later, the patient noted swelling in the left gluteal region. This mass became progressively larger and more painful. On physical examination, he was found to have a fixed, painful, hard mass which was 12 cm. in diameter in the left gluteal region. Flexor motor weakness and diminished deep touch in the left foot were noted. The impression was a soft tissue tumor of the left gluteal region, type

FIG. 3. This photograph depicts the case of T. D., who demonstrates a post-traumatic aneurysm of the popliteal artery.

undetermined. Lumbar aortograms were not diagnostic.

On June 20, 1958, the patient, on exploration of the left gluteal mass, was found to have a partially clotted aneurysm of the left gluteal artery, probably secondary to arteriosclerosis. With retroabdominal exposure and control of the left internal iliac artery, the gluteal artery aneurysm was excised, and the left gluteal artery ligated. The patient had a normal postoperative course, and follow-up over the past year has shown no further abnormality (fig. 4, *A* and *B*).

Arteriosclerotic Aneurysm of the Hepatic Artery

Case 5. H. S., No. A771041, a Negro man, aged 49, was admitted on November 19, 1957, with a history of hematemesis and melena of 2 months' duration. Elsewhere, an exploratory laparotomy 2 weeks before admission revealed a dilated celiac axis, superior mesenteric artery and an aneurysm of the hepatic artery. The patient continued to bleed via the gastrointestinal tract during postoperative course and was referred to this hospital. Retrograde aortograms suggested a hepatic artery aneurysm and showed a dilated superior mesenteric artery.

On December 6, 1957, this patient underwent thoracoabdominal laparotomy. The hepatic artery was found dilated to 7 cm. in diameter and was tortuous and thrombosed in its distal two thirds. After resection of the aneurysm and evacuation of the old thrombus, the distal hepatic artery was found to be completely occluded with an old fibrotic thrombosis which extended into the distal branches. No lumen could be demonstrated. The proximal hepatic artery was closed. The patient developed pneumonia, uremia and pyelonephritis in the postoperative course, but he survived and was discharged to be followed in the clinic. He subsequently developed incapacitating arthritis, became addicted to opiates and died about 14 months after operation in a state of debilitation (fig. 5).

Traumatic Aneurysm of the Brachial Artery

Case 6. E. B., No. A67494, a Negro man, aged 39, was admitted on April 7, 1957. He had received

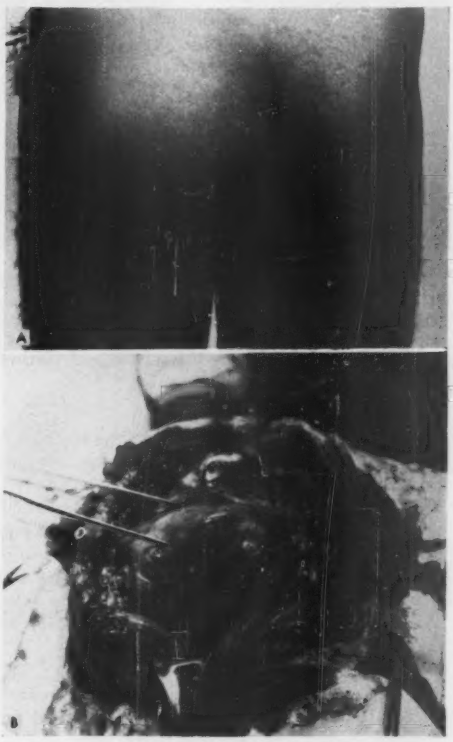

FIG. 4. *A*. This photograph illustrates the gluteal aneurysm in the case of R. J. The mass is seen to occupy the entire left buttock. *B*. This shows the aneurysm at time of operation. The gluteal artery in this case was ligated by circumferential ligatures. This gluteal artery aneurysm was excised.

FIG. 5. This aortogram illustrates the case of H. S., who developed a hepatic artery aneurysm. The splenic and renal arteries are well seen. The superior mesenteric artery is markedly dilated, and the hepatic artery is thrombosed, obviating the passage of dye.

a knife wound of the left biceps 3 years before admission. Four weeks before admission, the patient began to have swelling and pain in the left arm. On physical examination, he was found to have swelling of the medial one-third of the left arm measuring approximately 15¼ inches in circumference. The mass was weakly pulsatile and nontender. Impression on admission was false aneurysm, post-traumatic, of the left brachial artery.

An exploration of the mass on April 29, 1957, revealed a false aneurysm containing organized blood clots. The aneurysm was resected, and the brachial artery was repaired by primary end-to-end anastomosis. Postoperatively, there were good distal pulses, and the convalescence was uneventful (figs. 6, 7, and 8).

Axillary Aneurysm of Traumatic Origin

Case 7. M. M., No. 16369, a white man, aged 37, sustained an injury by a bullet wound to the left anterior shoulder in June 1958. Soon after the injury he noticed swelling in the left axillary region, localized pain, progressive weakness of the left arm, numbness and paresthesias in the left fingers, and muscular tremors in the deltoid area. With progression of these symptoms, he was admitted to the hospital on July 1, 1958. Physical examination revealed a healthy white man with a pulsatile mass, 10 cm. in diameter, in the anterior axillary fold over which a loud bruit was heard. Weakness of the triceps on the left was noted.

FIG. 6. This photograph is of the left arm of patient E. B., who developed post-traumatic false aneurysm of the brachial artery.

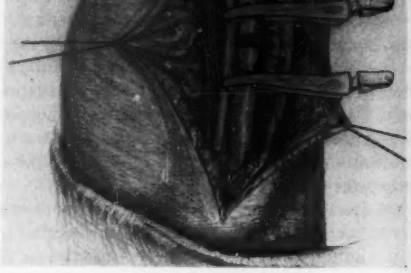

FIG. 7. This shows the brachial artery in patient E. B. at operation, positioned for repair.

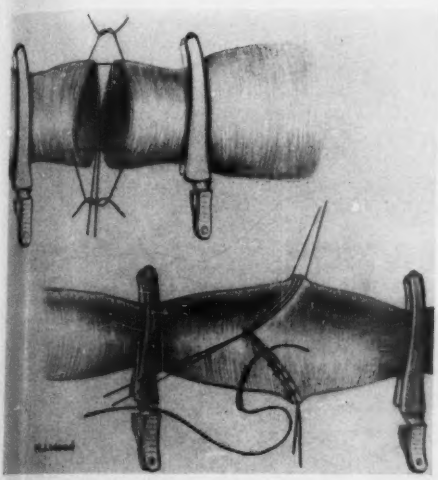

FIG. 8. This drawing illustrates the method of repair in end-to-end arterial anastomosis, but additionally includes the placement of 3 equally spaced sutures to facilitate posterior suturing and shows the technique of interrupted simple sutures.

Impression on admission was post-traumatic axillary artery aneurysm.

The mass was explored on July 7, 1958, and a false aneurysm of the axillary artery was found. The injured portion of the artery was excised, and end-to-end repair was performed on the artery. The patient's postoperative course was uncomplicated, and he was discharged on July 18, 1958, with good peripheral pulses. On follow-up, the left arm function was good, and there was no muscular weakness (fig. 9).

Carotid Artery Aneurysm of Traumatic Origin

Case 8. T. K. D., No. A42782, a white male child, aged 7, had the left side of his neck lacerated by broken glass 7 months before admission in February 1953. The external jugular vein had been ligated at the time of the injury. Two weeks after the accident, the patient again bled from the wound of the neck. At that time, it was necessary to ligate the common carotid artery to control hemorrhage. Immediately afterwards, right hemiplegia was noted. During the subsequent 5 months, he regained partial function of the right side. On admission to Roper Hospital, a pulsatile mass was noted in the left side of the neck over which a distinct bruit was heard. Impression on admission was post-traumatic false aneurysm of the left carotid artery.

On February 7, 1955, the patient underwent exploration of the left carotid artery from its origin to the base of the skull. The common carotid artery was found to be patent and normal, except for a saccular aneurysm, 4 cm. in diameter, which was resected. An endoaneurysmorrhaphy was accomplished without interrupted carotid flow. There was no sign of the previous carotid ligature. The patient's recovery was uneventful, and the hemiplegia was noted at a later date to be improved sufficiently to allow him to ride a bicycle to school (figs. 10 and 11).

Aneurysm of Carotid Artery of Congenital Origin

Case 9. A. R. F., No. A17073, a Negro girl, aged 14, was admitted to Roper Hospital on February 6, 1956, with the history of intermittent right chest pain and a mass on the right side of the neck since 1942. She had previously been hospitalized for repeated bouts with pneumonia.

On admission, there was a 5- by 5-cm. pulsating mass seen to extend behind the angle of the mandible in the right side of the neck, over which there was a palpable thrill and audible bruit. No pulsations were felt in the left carotid artery. The left radial artery pulse was barely perceptible. X-rays showed an aneurysm of the right carotid artery, heavy calcification in the arch of the aorta, and chronic lung disease with contraction in the right hemithorax. Angiocardiograms revealed non-

FIG. 9. This photograph shows the post-traumatic aneurysm of the axillary artery as depicted in the case of M. M. The artery was repaired by end-to-end anastomosis.

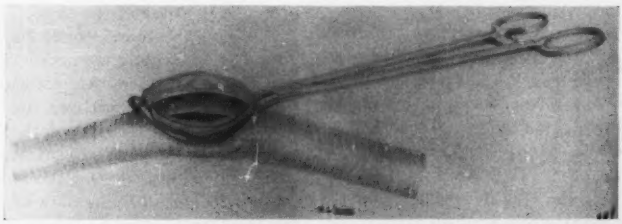

FIG. 10. This photograph demonstrates the technique of endoaneurysmorrhaphy without interrupting the blood flow. This procedure was carried out in the case of T. K. D., who had a carotid artery aneurysm.

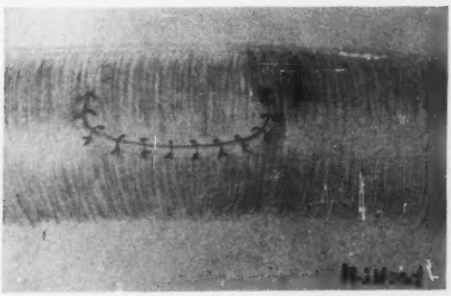

FIG. 11. This photograph shows the final closure of the defect in the arterial wall of patient T. K. D. with a portion of the false aneurysmal sac to support the direct repair of the artery.

FIG. 12. This photograph depicts patient A. R. F. and shows the aneurysm of the right carotid artery. The site of exploration of the left carotid artery is noticeable.

FIG. 13. This is an aortogram showing the narrowing of the aorta and the atresia of the left subclavian artery which were also found in patient A. R. F.

visualization of the right pulmonary artery, and nonopacification of the left carotid subclavian arteries. On February 9, 1956, under local anesthesia, the left side of the neck was explored, and no carotid artery could be identified. Because of the lack of blood flow in the left carotid and the left vertebral arteries, it was thought that attempts toward resection and repair of the right carotid artery aneurysm were contraindicated, and she was discharged to be followed in clinic. The final diagnosis was aneurysm of the right carotid artery and atresia of the left carotid, left subclavian and right pulmonary artery. Subsequently, the girl has developed normally, and there has been no progression in the size of the carotid artery aneurysm (fig. 12 and 13).

Radial Artery Aneurysm of Traumatic Origin

Case 10. A. F., No. 75927, a Negro man, aged 41, stated that 1 month before admission he accidentally struck his left wrist with a wrench, producing

FIG. 14. This photograph shows the radial artery aneurysm of patient A. F., which developed subsequent to blunt trauma of the wrist.

pain and a small amount of swelling. The swelling continued throughout the month and became pulsatile. On admission in April 1955, an expansile, pulsatile mass, 3 cm. in diameter was seen at the radial aspect of the left wrist. Obliteration of the radial artery proximal to the mass decreased the size and diminished the pulsations in the mass. The impression on admission was aneurysm of the radial artery. At operation on April 28, 1955, a saccular aneurysm was found to arise from the radial artery. A pneumatic tourniquet, which had been previously placed around the arm, was inflated. The sac was excised, and end-to-end anastomosis was established. The postoperative course was uncomplicated, and there were normal pulsations in the radial artery (fig. 14).

DISCUSSION

The first patient illustrates luetic false aneurysm of the popliteal artery. The repair in this case was excision of the false sac and repair of the defect in the arterial wall, constituting an endoaneurysmorrhaphy. Had length permitted, resection of the involved segment and end-to-end anastomosis could have been done.

The second patient, J. H., with arteriosclerotic aneurysm of the femoropopliteal artery presents little difficulty in diagnosis. The advanced age of the patient, the multiple signs of arteriosclerosis, and the physical components of the popliteal mass give a reliable clinical impression. This case illustrates the advantage of the plastic prosthesis as an arterial graft. No difficulty was encountered in suture of the ends of the graft to the arteriosclerotic vessel.

The third case, T. D., illustrates a post-traumatic false aneurysm of the popliteal artery. Resection of a portion of the artery, together with the aneurysmal sac, was necessary. Although replacement with an arterial homograft was successful, this type of graft has since been replaced largely by the use of plastic prostheses as grafts. This patient also demonstrates the length of time occasionally intervening between the time of trauma and the aneurysmal dilation.

These first three cases have the same artery in common, but they show three different etiologic agents and three different modes of repair of the aneurysm.

The fourth patient, R. J., with an arteriosclerotic aneurysm of the left gluteal artery, demonstrates painful debilitation which may be caused by aneurysms. This case also typifies the minimum defect produced by simple ligation and excision of aneurysms at sites where there is adequate collateral circulation.

The fifth patient, H. S., presents the unusual role of aneurysms associated with gastrointestinal bleeding. Attempt at curative end-to-end repair was thwarted in this case by fixed thrombosis in the distal artery. Resection of the aneurysm was necessary to obviate the possibility of fatal rupture or further hemorrhage into the common duct. Re-establishment of arterial flow was impossible.

The sixth patient, E. B., typically demonstrates a large number of aneurysms in which a major artery, as in this case, the brachial, is involved in an accident. This case also serves to show the proportion to which a peripheral artery aneurysm may expand and the time interval between injury and ensuing difficulty.

The seventh patient, M. M., with a post-traumatic false aneurysm of the axillary artery, serves to point out that there is not always a lengthy latent period of aneurysmal formation. This aneurysm formed within a few weeks. It is also noted that neurologic involvement is frequently due to pressure injury upon adjacent nerves. In the axillary region, end-to-end anas-

tomosis is made easier by laxity and flexibility of the artery.

The eighth patient, T. K. D., with post-traumatic aneurysm of the carotid artery, serves to illustrate endoaneurysmorrhaphy. The entire wall of the artery was not involved. It had previously been established that this child could not tolerate occlusion of the carotid. Accordingly, the neck of the aneurysm was occluded in such a manner as to allow normal carotid flow but to obliterate access of blood into the aneurysm. Partial excision of the aneurysm, closure of the defect and imbrication of the aneurysm wall over the defect afforded adequate repair of the artery.

The ninth patient, A. R. F., with multiple congenital anomalies, including an aneurysm of the carotid artery, illustrates the meticulous evaluation necessary in these patients from the point of view of their entire vascular structure, despite apparent localized disease.

The tenth patient, A. F., with aneurysm of the radial artery, secondary to blunt trauma, shows that the precipitating cause of the aneurysmal formation in peripheral arteries need not necessarily be a penetrating wound. Weakening of the wall of the artery is the only necessary precipitating cause of aneurysmal formation, whether that weakening be due to arteriosclerosis, arteritis, blunt trauma, and so forth. With knowledge that the wall has been weakened, as in this case, it is best to resort to resection of the portion and primary anastomosis.

In summary, ten illustrative cases of peripheral artery aneurysm involving the carotid, axillary, brachial, radial, hepatic, gluteal, femoral, and popliteal arteries are presented.

It is seen that trauma plays a major role in the formation of peripheral artery aneurysms, usually with the production of a false aneurysmal sac. Other etiologic entities must be constantly considered when viewing pulsatile tumors without history of trauma. At the time of repair, the use of the sac in the repair as in the Matas endoaneurysmorrhaphy, the resection of the sac and primary aneurysmorrhaphy, resection and end-to-end anastomosis, or resection and graft replacement must be kept in mind. The pneumatic tourniquet, positioning of the limb to insure safe anastomosis, and the recent strides in better vascular prosthesis invaluably aid the surgeon in the treatment of peripheral artery aneurysms.

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Charleston, South Carolina

CARDIAC ARREST: ROUTINE USE OF A CARDIAC MONITOR

JAMES H. YOUNG, M.D.

Anderson, South Carolina

The first recorded case of so-called cardiac arrest at the Anderson Memorial Hospital occurred on October 15, 1950. This was a case of an operating room death in a patient with a crushed chest; therefore, this probably should not be classified as primary cardiac arrest. However, we have reviewed all of our records from January 195C through December 1959, feeling that it would be useless to start before the year that the first diagnosis was made. This report deals with the analysis of these cases and our experience with the routine use of a cardiac monitor for the past two and one-half years

DEFINITION

There have been many definitions of primary cardiac arrest in the literature. One given by Berne[1] is my choice. "Cardiac arrest is potentially avoidable, usually reversible ventricular asystole with or without fibrillation, precipitated by the effects of anesthesia alone, of surgery alone, or of the two in combination."

OCCURRENCE

During the 10-year study period ending December 1959, we have had 54,986 surgical procedures, and our record room has tabulated 38 cases of so-called primary cardiac arrest (table 1). Several of these were medical cases and were omitted from this surgical study. Others fell under the category of moribund preoperative condition or fatal injury or uncontrollable hemorrhage. Two cases were not designated as cardiac arrest, but were classified as respiratory failure, and death occurred later. These 2 cases were actually cardiac arrest and are included in this study. There were 29 cases of primary cardiac arrest which will be analyzed. Two of these may have been primary respiratory failure, although they are not the 2 mentioned above. The first of these was an arrest which occurred following lobectomy, when a tracheostomy tube was to have been replaced within a previously existing tracheostomy. This attempt failed, and during manipulation, cardiac arrest occurred. The second case was a patient with primary carcinoma of the trachea. Following withdrawal of the bronchoscope, the patient went into laryngospasm, and the scope could not be passed again. Perhaps these 2 cases should have been omitted from this study since they may very well be respiratory arrest, but we have considered them to be within the realm of this study. This represents an over-all incidence of 0.05 per cent, or 1 case per 2000 operations. In 1956 and 1957, we had our highest incidence, 8 cases of cardiac arrest with an incidence of 0.13 per cent. Since we began using the cardiac monitor 2½ years ago, we have had 5 arrests, 1 of these being an extremely poor surgical risk.

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ANALYSIS OF CASES

1. Age. Some writers state that the increased incidence of arrest is due to the fact that the surgical population is older now than it was a decade ago. Our arrests have occurred at all ages. One can notice that 4 arrests in our series occurred in the 1st decade of life, and this represents a high incidence in our hospital (table 2).

2. Type of anesthesia. Spinal anesthesia as a sole anesthetic agent has been a very safe anesthetic in our hospital, but for the past few years has been used very rarely. In conjunction with Pentothal or Surital it has been used frequently and has been the anesthetic agent in 10 of the cardiac arrests that we have had. Open drop ether has been the agent in 4 cases. Surital or Pentothal and succinylcholine have been the agents in 14 cases, 9 of these during induction of anesthesia. Topical anesthesia, Cyclaine, was used in 1 bronchoscopy which resulted in arrest (table 3).

3. Time of onset. One-third of our arrests occurred during induction of anesthesia before any surgical procedure had been started. Fourteen occurred while the procedure was being performed, several of these due to gradual deterioration of the patient's condition. Six of our cases

TABLE 1

Cardiac arrest incidence

Year	Operations	No. of Arrests	Incidence
			%
1950	4023	0	0.00
1951	4808	1	0.03
1952	5184	3	0.06
1953	5282	2	0.04
1954	5214	1	0.02
1955	5409	1	0.02
1956	6147	8	0.13
1957	6474	8	0.12
1958	6190	2	0.03
1959	6255	3	0.03

TABLE 2

Age distribution

Age	No. of Arrests
yr.	
0–9	4
10–19	3
20–29	7
30–39	2
40–49	3
50–59	4
60–69	2
70–79	4

TABLE 3

Anesthetic agent

Anesthesia	No. of Arrests
Spinal, with or without Pentothal	10
Ether, open drop	4
Pentothal and muscle relaxant	14
Topical	1

occurred after the procedure had been completed and while the wound was being closed or the dressing applied (table 4).

4. Anesthetist. Almost 50 per cent of our cases occurred while an "anesthesiologist" was administering the anesthetic agent. These 2 physicians in our community get the most difficult cases and administer a larger number of anesthetics than the generalists. Six of the arrests occurred with 6 different physicians and 9 of the arrests have occurred with 3 generalists (table 5).

5. Treatment: route of massage. Of the total 29 arrests, 25 patients received cardiac massage (19 by the transthoracic approach and 6 by the abdominal approach through the diaphragm), and 4 of them recovered (2 without residual). Four were not massaged. One of these arrests occurred early in 1951 following a spinal for a transurethral resection; all resuscitative measures, short of massage, were attempted, but failed. Another was a 6-year-old child who was returned to the recovery room after a strabismus operation and was resuscitated with intracardiac Adrenalin. The 3rd was a case of surgical repair of a cleft palate, and the patient was resuscitated by means of intracardiac Adrenlin. The 4th was a case which occurred during insertion of a tracheostomy tube following lobectomy for bronchiectasis. In 4 of these cases in which there was no massage, death occurred, although resuscitative measures were successful temporarily in 2 of them (table 6).

6. Outcome of treatment. Of these 29 cases, 24 patients died within 10 days; the majority died in the operating room. Three recovered with definite neurologic defects and were discharged from the hospital. Two recovered completely and have no residual neurologic defects (table 7).

7. Type of surgery. The type of surgery does not seem to be too important in our series. The

TABLE 4

Time of arrest

Time	No. of Arrests
Before surgery	9
During surgery	14
After surgery	6

TABLE 5

Anesthetist	No. of Arrests
"Anesthesiologist"	14
Generalist	15

TABLE 6

Treatment of cardiac arrest

Treatment	No. of Arrests
Transthoracic massage	19
Transabdominal	6
Neither	4

TABLE 7

Outcome

No. of Arrests	Route	Died	Recovered with Resuscitation	Recovered without Resuscitation
19	Thoracic	15	2	2
6	Abdominal	5	1	0
4	Not massaged	4	0	0

only significant fact that we could note seemed to be that biliary surgery carries an increased risk for arrest.

8. Prevention. It is difficult to judge in some of these cases whether or not cardiac arrest could have been prevented. However, with careful preoperative preparation, with adequate and recent protection with atropine, with careful administration of the anesthetic agent and with the avoidance of strong stimulation under light anesthesia, I believe that one-half of the arrests could have been prevented. There were some patients who were extremely poor risks and were recognized as increased hazards.

POSSIBLE PROBLEMS WITH THE CARDIAC MONITOR

Since September 1957, we have used the monitor-pacemaker, Electrodyne PM-65, on virtually all of our surgical procedures that require anesthesia, and therefore have made certain observations.

1. We found that a false alarm can be caused by inadequate contact of the skin electrodes, and this, in turn, might be due to insufficient quantity of electrode paste.

2. A long procedure may be associated with excessive perspiration and a loss of contact of the electrodes.

3. The electrodes, skin or needle might become displaced under the drapes.

4. The sensitivity setting on the monitor might be set too low, so that a decrease in the voltage of the QRS impulse may cause it to fail to indicate on the monitor, thereby causing a false alarm. Because of this, we have adopted the policy of setting the sensitivity as high as possible without getting a double indication from picking up the T wave.

BENEFITS OF THE MONITOR

1. Perhaps the most striking demonstration of the value of the cardiac monitor that we have experienced occurred in a patient being anesthetized for thyroidectomy. The monitor was placed on her chest, and, as she was being intubated, she showed marked irregularity with inversion of the T wave. Because the changes persisted, we cancelled her surgery and returned her to the recovery room. An electrocardiogram was taken and was negative immediately following the incident. However, during the next few days, repeated electrocardiographic tracings were taken and showed a persistent defect interpreted by a cardiologist as an acute infarction. A fatal outcome might have occurred had we ignored the monitor and proceeded with surgery.

2. One of my associates had an experience in which the monitor probably was responsible for saving the patient's life. A 3-month-old infant was operated upon for hypertrophic pyloric stenosis, and respiratory arrest occurred 3 or 4 times during the operative procedure. The marked irregularity of the monitor motivated the surgeon to discontinue surgery several times, avoiding the dangerous combination of hypoxia plus vagal stimulation.

3. Another example of the benefits of the monitor can be shown in the case of a 60-year-old man who was undergoing cholecystojejunostomy for a nonresectible carcinoma of the head of the pancreas. The monitor showed increased bradycardia and irregularity with premature systoles. Surgery was discontinued until the source of trouble could be found. Aspiration of the trachea through the endotracheal tube yielded a large quantity of mucus, which had caused partial obstruction of the trachea and resultant hypoxia. After removal of the mucus and adequate administration of oxygen and anesthesia, the patient's pulse returned to normal, and the monitor showed a normal tracing.

4. An elerly woman was undergoing oral surgery with an endotracheal tube in place and the drapes covering the patient, except for the operative field. About midway through the procedure, with no change in position of the patient or any of the personnel, the monitor showed a slowing pulse with marked irregularity. Cyanosis developed, and surgery was discontinued. The anesthetist checked the rubber tubing from the machine, heard adequate breath sounds and started to check the soda lime to see if it were saturated with carbon dioxide. However, because of the marked bradycardia and irregularity, the

drapes were quickly removed and the source of trouble was found to be that one of the tubes had become disconnected at the Y connection tube with the endotracheal tube. I believe that the visual and auditory warning that the surgeon was receiving from the monitor helped him to assist the anesthetist in immediately finding the cause of the difficulty. Perhaps these few moments made the difference between an arrest and nonarrest.

5. There have been 2 cases in which the alarm has gone off, and we are uncertain as to the cause. The probabilities are that they were cases of cardiac arrest which responded immediately to stimulation. However, because we did not have to massage the heart, and since we had no direct evidence of cardiac arrest, they are not classified as such.

CASE REPORTS

Case 1. This 88-year-old woman underwent pinning of a fractured hip. The monitor and pacemaker were set to go off on automatic, and the QRS impulse was not received for a period of 6 sec. In the middle of the operative procedure, the alarm went off. The patient received approximately 1 mm. of stimulation from the pacemaker. The pacemaker was then shut off, and she was placed back on monitor, which showed irregular but effective impulses associated with a good palpable pulse. Within a few minutes more, the pulse returned to normal. Her blood pressure was difficult to maintain for the 24 hr. following surgery, but she recovered completely. Two years later, she fractured the other hip.

Case 2. This 41-year-old woman underwent simple mastectomy. Needle electrodes were used on the extremities so that the electrodes were not in the operative field. Of course, with needle electrodes on the extremities, we could not use the pacemaker on automatic. The QRS impulse failed to register for 5 sec.; the alarm went off, and the chest was pounded several times. The monitor immediately began to register again, and the pulse returned to its strong beat. She had absolutely no sequela.

SUMMARY

1. Cardiac arrest is the major cause of operating room deaths.

2. In our series, age is not an important factor.

3. Anesthetic factors contributing to the development of cardiac arrest are: (a) hypoxia, (b) overdose of anesthetic agent, (c) insufficient anesthesia in the presence of strong sensory stimuli, (d) problems associated with rapid intubation technique, and (e) misplacement or migration of endotracheal tube.

4. Surgical factors contributing to the development of cardiac arrests are: (a) inadequate preoperative preparation, (b) unwise and persistent manipulation of viscera, and (c) insufficient communication between the surgeon and the anesthetist.

5. The transthoracic approach for cardiac massage is the route of choice for the following reasons: (a) it is a rapid approach to the heart regardless of the site of primary surgery; (b) the heart may be visualized to differentiate between fibrillation and asystole and drugs may be administered into the heart without endangering the coronary vessels; (c) electrodes for defibrillation and/or pacemaker can be applied accurately; and (d) prolonged massage is more easily accomplished by this route.

6. Cardiac arrest is a preventable catastrophe in most instances. In reviewing our patients, I believe that one-half the arrests could have been prevented with careful attention to detail. Or, if we put it in a different way, I think that it would be possible to reduce, by at least 50 per cent, the incidence of cardiac arrest at our hospital.

7. The cardiac monitor does not replace careful observation by the anesthetist, but it is an extremely valuable adjunct to the management of surgical patients in the operating room and the recovery room. I believe that it should be used on every patient undergoing a surgical procedure that requires an anesthetic of any kind.

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MANAGEMENT OF BRONCHOCUTANEOUS FISTULA*

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In the past four years we have treated seven patients with complications of chronic empyema and bronchocutaneous fistula following surgery. This is a report of those cases and our management of them. We performed the original operation on one, case 3; all others were done at other institutions.

COMPLICATIONS

The incidence of complications following surgery for pulmonary tuberculosis can be reduced by:

1. Evaluation of the patient. The general condition of the patient as determined by weight, blood volume, serum proteins, and the presence of diseases in other organs is most important. Involvement of the opposite lung will increase the incidence of complications and mortality. The lung should show maximal response to treatment or stability. Failure of previous resections will indicate the probability of complications with subsequent procedures. The mental attitude exerts a marked influence. Patient 1 could not be healed until a wire mesh cage was placed over his tracheostomy to prevent his increasing the intrathoracic pressure and blowing out his bronchial stump. We feel that bronchoscopy is rarely necessary in the evaluation of those patients with bronchocutaneous fistula. Lipiodol instillation is safer and gives objective demonstration of the fistula and the empyema space. Progress may be determined by comparing interval examinations.

2. Evaluation of chemotherapy status. Complications of surgery are rare, 5 per cent, in patients undergoing original treatment if the surgery is performed at the proper time. With resistant organisms or previous therapy failure, complications may be expected 5 times as frequently, 25 per cent.

3. Collapse therapy. In the group with resistant organisms or previous therapy failures, one should consider collapse therapy either before resection or concomitantly. Preresection operations have consisted of thoracoplasty or lucite plombage, and concomitant procedures have consisted of thoracoplasty or air plombage.

4. Postoperative care. Postoperative complications should be treated early. This includes maintaining a patent airway by tracheostomy, if necessary, preventing abdominal distention, maintaining the blood volume, and closed thoracotomy drainage of residual air pockets. Persistent adequate drainage may result in healing.

TREATMENT

The treatment of these complications was accomplished by the use of the standard Alexander thoracoplasty, the modified Schede as described by Kergin,[1] partial scapulectomy, and partial claviculectomy as described by Lambert.[2] These were used individually or collectively.

CASE REPORTS

Case 1. W. F. S., No. 117397, a 34-year-old white man, was diagnosed as having pulmonary tuberculosis in the left apex, in 1950. A left apicoposterior segmental resection and posterior thoracoplasty of the 2nd, 3rd, and 4th ribs were performed in February 1952, simultaneously sputa were positive on smear and culture. A bronchocutaneous fistula resulted. A left upper lobectomy was performed in December 1952, and his sputa were still positive. The fistula recurred in August 1953. In February 1954, a left lower lobectomy was performed and the 5th and 6th ribs were resected. The fistula recurred and was closed 3 weeks later. The fistula persisted and he was transferred to Kennedy Veterans Administration Hospital.

In October 1954, a pedicled muscle graft to the bronchus and revision of the thoracoplasty were performed. On the second postoperative day, he held his nose, forcibly exhaled, and recreated his fistula. In December 1955, closure of the left primary bronchus and tracheostomy were performed. In March 1956, the midportion of the left

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FIG. 1. End result in case 1; all others are similar.

clavicle was resected, and in June 1956, the tip of the left scapula was resected. Three weeks later, in June 1956, a final closure of the left primary bronchus was performed. In September 1956, the tracheostomy fistula was closed. In February 1957, he died in another hospital 24 hr. after fracturing a femur. His fistula was still closed (Fig. 1).

Case 2. C. E. T., No. 143634, a 45-year-old white man, developed pulmonary tuberculosis in 1953, and in August 1954, he had a right pneumonectomy. He developed empyema in the space left from the pneumonectomy, and this was treated with a thoracoplasty, which was followed by a bronchocutaneous fistula. He was transferred to Kennedy Veterans Administration Hospital in May 1955. In July 1956, he had revision of the thoracoplasty, closure of the bronchial stump, and partial resection of the clavicle and scapula in one stage. In August and September, abscesses developed about the posterior tube with sinus tracts leading to the bronchial stump. An abscess developed in the wound in February 1957, but by March 1957 all wounds were healed. Last sputum, taken in October 1957, was positive on culture. He was seen in October 1958 and was healed.

Case 3. R. I. C., No. 149062, a 40-year-old white man, proved to have pulmonary tuberculosis in 1950. He received chemotherapy and pneumoperitoneum from January 1951 to May 1954. At that time, sputa were positive and organisms resistant to drugs. In July 1958, at Kennedy Veterans Administration Hospital, right upper lobectomy and air plombage were performed. He developed a bronchopleural fistula and empyema. In August 1958, a right, 6-rib modified Schede thoracoplasty with bronchial stump closure was performed. On the second postoperative day, the bronchial closure blew out, and a bronchocutaneous fistula occurred. In October 13, 1958, the thoracoplasty was revised, the tip of the scapula was resected, and the fistula was closed. On October 17, 1958, the middle one-third of the clavicle was resected to allow collapse of the shoulder girdle muscles against the mediastinum. A small fistula still persists (figs. 2 and 3).

Case 4. W. E. D., No. 153269, a 47-year-old white man, had cavernostomy performed 13 times from May 1947 to October 1948. He also had muscle and fascia grafts performed for a nonspecific abscess in the right lung. In October 1948, a right upper lobectomy and resection of the superior segment of the right lower lobe were performed. The fistula persisted. In November 1949, a pedicled muscle graft closure of the fistula was unsuccessful.

FIG. 2. Case 3 shows a demonstration of lipoidol instillation through thoracotomy tube and a persistent bronchial fistula 9 mo. after his last operation. Progressive diminution in the size of the space was shown objectively by interval instillation.

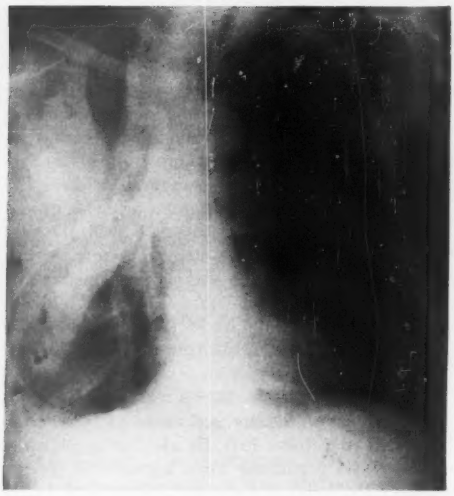

FIG. 3. After right upper lobectomy in case 3, modified Schede and tip of scapula resection an apical space remains. The effect of the clavicle propping open the apical space is clearly shown.

Periodic mobile unit x-rays were taken, and in the summer of 1958, a change in the left lung was noted. Sputum smears were positive. He entered Kennedy Veterans Administration Hospital in September 1958. Streptomycin and isoniazid were given, and sputum smears were negative in January 1959. In May 1959, revision of the right thoracoplasty and tracheostomy were performed. Cultures have been negative since July 1959, and his fistula is healed.

Case 5. E. E. G., No. 154864, a 52-year-old white man was diagnosed as having pulmonary tuberculosis in 1954, and a Monaldi operation was performed in the left apex in 1956. A 5-rib left thoracoplasty was performed in 1957 with a persistent bronchocutaneous fistula. His sputa remained positive and organisms, resistant. In January 1959, he was transferred to Kennedy Veterans Administration Hospital, and the thoracoplasty was revised, the tracheocutaneous fistula was closed, and a tracheostomy was performed. His fistula was healed, but his sputa were still positive at the time he was discharged, against medical advice.

Case 6. G. D. J., No. A3229, a 36-year-old white man, developed pulmonary tuberculosis in 1952, and in January 1953, right upper lobectomy was performed. In May 1953, a right thoracoplasty was added. He was home 1 year with negative sputum, and then he developed empyema. In 1955, a decortication and a revision of the thoracoplasty were accomplished. In 1956, an axillary bronchocutaneous fistula appeared. In May 1958, a bronchoesophageal fistula was diagnosed, and permanent gastrostomy was performed. Smears and culture of the sputa were negative. He was transferred to Kennedy Veterans Administration Hospital in June 1959, and revision of the thoracoplasty, closure of the bronchus and esophagus, resection of the lower one-third of the scapula and tracheostomy were performed. Two months postoperatively, the esophageal fistula recurred. In October 1959, the middle one-third of the clavicle was resected and reapproximated with a wire loop; the esophagus was closed; and the scapula inferior to the spine was resected. It is too soon postoperatively to evaluate the final result (fig. 4).

Case 7. W. E. W., No. A3360, a 32-year-old white man, was diagnosed as having tuberculosis in June 1957. In June 1958, a right upper lobectomy and resection of the superior segment of the right lower lobe were performed. Bronchopleural fistula occurred. In December 1958, a 5-rib thoracoplasty, partial scapulectomy and closure of the bronchus were performed, and there was collapse of the lung and development of a large empyema space. Two weeks postoperatively, emergency tracheostomy was performed. Sputa were negative. In July 1959, the fistula was reclosed and the tracheostomy reopened. The fistula recurred, and he was transferred to Kennedy Veterans Administration Hospital. In October 1959, resection of the middle one-third of the clavicle and reapproxima-

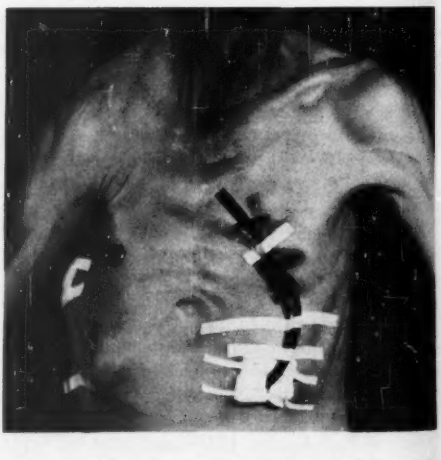

FIG. 4. There is a shoulder girdle deformity in case 6 after resection of middle ⅓ of the clavicle and approximation of the ends with a wire loop.

TABLE 1

Case history

Case No.	Age, Color, Sex*	Duration of Fistula	Operation on Lung, Date	Thoracoplasty, Date	Scapula Resection, Date	Clavicle Resection, Date	Tracheostomy, Date	Result and Follow-Up†
1	34, W, M	*yr.* 2½	Left apical segment, 2/52 Left upper lobe, 10/52 Left lower lobe, 2/54	2, 3, 4 rib Alexander, 2/52 5, 6, rib Alexander, 2/54 Schede and fistula closure, 10/54	Lower ⅓ and fistula closure, 6/56	Mid ⅓, 3/56	And fistula closure, 12/55	Healed, 6 mo.; died from other cause
2	45, W, M	2	Right pneumonectomy, 8/54	Alexander, 10/54 Schede and fistula closure, 7/56	Lower ⅓, 7/56	Mid ⅓, 7/56		Healed, 3 yr.
3	40, W, M	1/12	Right upper lobe, 7/58	Schede and fistula closure, 8/58 Schede, 10/58	Lower ⅓ and fistula closure, 10/58	Mid ⅓ 10/58		Small fistula persists, 19 mo.
4	47, W, M	12	Right upper lobe and superior segment; right lower lobe, 10/48	Cavernostomy, 13 times, 1947 and 1948 Fistula closure, 11/49 Schede and fistula closure, 5/59			5/59	Healed, 10 mo.
5	52, W, M	3	Monaldi Left apex, 1956	5 rib Alexander, 1957 Schede and fistula closure, 1/59			1/59	Healed, 10 mo.
6	36, W, M	3	Right upper lobe, 1/53	Schede and fistula closures, 6/59	Lower ⅓, 6/59 Mid ⅓ and esophageal fistula closure, 10/59	Mid ⅓, 10/59	6/59	Bronchial fistula healed, 9 mo.; esophageal fistula *unhealed*, 7 mo.
7	32, W, M	1½	Right upper lobe and superior segment Right lower lobe, 6/58	5 rib Alexander and fistula closure, 12/58	Lower ⅓, 12/58	Mid ⅓ and fistula closure, 10/59	Reopened, 1/59; fistula closure, 7/59	*Unhealed*, 6 mo.

* W, white; M, male.
† Last recheck, March 1960.

tion with a wire loop were performed, and a thoracotomy tube was inserted into the empyema space. It is still too soon postoperatively to evaluate the final result.

DISCUSSION

In reviewing the literature on the subject of bronchial fistulas, there were no reports of all these procedures being used in an individual case. We certainly do not feel that this work is original, but the success obtained by the collective use of these well-known operations should be publicized.

At our hospital, the incidence of complications is 4 per cent with pneumonectomy or wedge

resection, 8 per cent with lobectomy and 12 per cent with segmental resection. Following evaluation of the patient and his chemotherapy status, we favor lobectomy over segmental resection if we expect more frequent complications.

SUMMARY

The incidence of complications following surgery for pulmonary tuberculosis can be reduced by evaluation of the patient, evaluation of the chemotherapy status, collapse therapy, and alert postoperative care. When complications occur, they may be treated by the use of the standard Alexander thoracoplasty, the modified Schede thoracoplasty, partial scapulectomy or partial clavículectomy. This is a report of the collective use of these procedures in seven patients (table 1).

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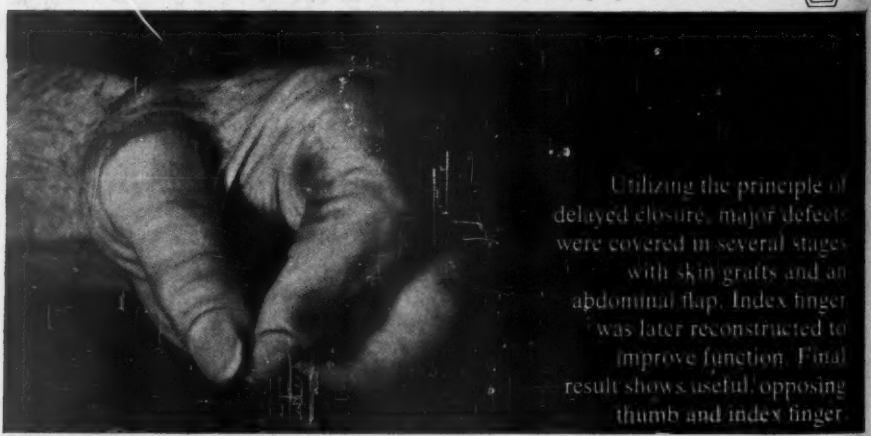

Utilizing the principle of delayed closure, major defects were covered in several stages with skin grafts and an abdominal flap. Index finger was later reconstructed to improve function. Final result shows useful, opposing thumb and index finger.

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